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A MONTE CARLO SIMULATION OF THE SACCS  
DATA PROCESSING CENTRAL

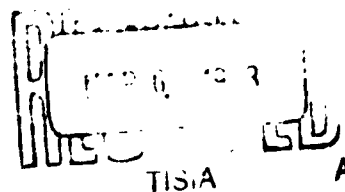
Marvin I. Gang

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18 June 1962

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SYSTEM DEVELOPMENT CORPORATION, SANTA MONICA, CALIFORNIA



18 June 1962

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SP-825

ABSTRACT

In the design of large-scale systems with stochastic inputs, computerized Monte Carlo simulation is often of great aid. Design decisions can be made quickly, and on the basis of trial in a simulated system rather than on conjecture. Such a simulation for the Data Processing Central of the SAC Control System is described. Limitations and applications of the simulation are also discussed.

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## I. Introduction

A major difficulty in the design process for a large-scale system with stochastic inputs is that generally the situation is so complex that it is virtually impossible to set up an analytical mathematical model or expression which can be manipulated to yield immediate answers of a type that facilitate a design decision. In such a situation, Monte Carlo simulation techniques can be used to great advantage. The complete system is divided into component parts each of which is readily describable by a probability distribution. At each point where a decision must be made, a random number is generated, which when applied to the distribution associated with the point serves as the decision maker. By this means experiments can be conducted on the model (simulated system) and the results noted. These results can be analyzed statistically to provide meaningful bases for design decisions.

An incidental but by no means insignificant additional benefit accruing from a simulation is that the details required for creation of a computer program often highlight gaps in the design and thus focus attention on specific problems which are as yet unresolved.

The present paper delineates the creation of a Monte Carlo simulation of the message traffic aspects of the Display Processing Central (DPC) of the Strategic Air Command Control System (SACCS), 465L. Hopefully, two results will be achieved: indication of the benefits available from future use of simulation in 465L design, and illustration of the application of Monte Carlo simulation to the design of a large-scale system.

## II. Early Studies

The earliest traffic studies performed at SDC (SACCS Department) were in the form of deterministic models of the various components of the 465L system. For example, consider the case of the Electronic Data Transmission Control Center (EDTCC). The EDTCC's functions were divided into three categories: input, processing and output. Service times for each task were predetermined, and the time to process batches of messages with specified routing characteristics was calculated. Additional time was allotted if two or more messages had the same destination (were competing for the same output transmission link).

Subsequent studies were statistical in nature allowing for random arrivals of messages and random service times for each function; that is, the arrivals and services followed predetermined probability distributions. The models also represented more closely the detailed equipment operation. For example, some crude consideration was given to the effects of message priority and internal processing sequence priority, the latter being particularly applicable to the EDTCC. It should be noted that mean message

arrival rates and service time data were obtained from message and equipment studies paralleling the efforts in the traffic area. In the execution of the traffic studies assumptions were made for which the primary justification was mathematical tractability of the model, and it became increasingly clear that to achieve more accurate results and to be able to evaluate design proposals in terms of their effect on traffic, more detailed and flexible models were needed. This led to the present effort--a computerized, Monte Carlo simulation of the DPC.

### III. Operation of the DPC\*

A block diagram of DPC operation is presented in Fig. 1.

#### Message Priority

The DPC recognizes three message priorities: Flash, Display Request\*\* and Regular. Flash messages are processed immediately on arrival, interrupting all processing except other Flash messages. Display Request and Regular messages are collected (batched) until a pre-specified time interval (the intervals for each are not necessarily the same) or a pre-specified number of one kind or the other are in the batch. When one of these conditions obtains, a request is initiated for operation of a Control Cycle.

#### The Control Cycle

The Control Cycle operates as a sequence of tasks performed in pre-specified order. There are a few cases where deviations from this order occur, but these are unimportant from a traffic point of view and have been ignored. The first task to operate is Data Preparation. This task sorts the messages in the batch according to the task with which each is associated. It also does some processing of each message. However, this is of no concern here, except insofar as it affects the operating time of the task. If there are any Display Requests to service, the next task to operate is Data Presentation. Display Requests are processed in order of arrival, and the displays outputted. Following Data Presentation, the Regular messages are processed, starting with the messages associated with the highest priority Regular task and proceeding in order of task priority until the messages associated with the lowest priority task have all been processed. Within each task

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\* The DPC operates via several program subsystems; e.g., Control, Planning, Training. Only the Control subsystem has been simulated. The simulation reflects the thinking on the Control subsystem as of January-February, 1962, and may have changed since.

\*\* The priority name is actually "Special." However, "Display Request" is the only message with this priority. Moreover, the operating rules are written for a one-message class.

the messages are processed in order of arrival. The content of a message can force other tasks (usually of a lower priority) to be operated. However, with the exception of messages forcing display outputs (and consequently, operation of Data Presentation) this effect is relatively minor from a traffic viewpoint. Only displays can be forced in the simulation. If messages force displays, completion of processing on these messages is deferred until all messages associated with the task have been completed. Data Presentation is then operated and the requisite displays outputted. The next lower priority task is then operated.

#### Flight Plan Processing

The lowest priority Regular task is Flight Plan Processing. However, this task is not part of the Control Cycle, and therefore is discussed separately. When all Regular messages have been processed, unless a request for initiation of Control Cycle exists, the Flight Plan processing task will operate. Flight Plans will be processed until all are completed or a Control Cycle request is made. It should be noted that once a Control Cycle begins, it is not interruptible by a request for a new Control Cycle -- only Flight Plan processing is interruptible.

#### Message Arrivals

Messages can arrive and be accepted by the DPC at any time. However, processing of these messages will be delayed as described in Message Priority and Flight Plan Processing.

#### IV. DPC Simulation

The simulation is described by the block diagram of Fig. 2, and a list of the input parameters selectable by the user, is given in Fig. 3. Note that the characteristics of the distribution of time for each processing function as well as the input message characteristics can be selected. A listing of the program instructions with explanatory notes is presented in the Appendix. Certain features of the simulation are described below.

#### Decision Making and Service Time Selection

Associated with each decision (including time interval selection) in the simulation is a probability distribution. When decision points are reached in the simulation, a random number is generated by the computer and combined with the probability distribution to result in a decision.

When the decision is the selection of a service time,  $t_s$  is incremented by the service time selected.



Example: Determination of time to operate Data Preparation Task.

Let us say  $t_s = 56.2$  sec. and the service time for operation of Data Preparation is equally likely to be anywhere between 10 and 25 sec. A random number is generated, say 0.7. The time interval for operation of Data Preparation is thus  $10 + 0.7 \times 15 = 20.5$  and  $t_s = 56.2 + 20.5 = 76.7$  sec. after completion of the task.

Random Number Generation

Because of the large number of decisions which are made in the course of operation of the simulation, a large supply of uniformly distributed random numbers is required. The congruence equation:

$$X_{n+1} \equiv X_n (2^7 + 1) + 227, 216, 619 \text{ MOD } (2^{28})$$

is used to generate pseudo-random numbers uniformly distributed between 0 and  $1024$ . These are then scaled to the interval  $(0,1)$ .\*

Message Arrival Time

It was decided to generate messages by means of the time between arrivals of messages (inter-arrival time) rather than in terms of the number of message arrivals in a given time interval. The latter method suffers from the lack of a fixed arrival time for a message (its arrival can be placed only as somewhere in the time interval). Also, a knowledge of the distribution of number of arrivals for one size time interval gives no knowledge of the number of arrivals in a different size time interval. The need for such knowledge will become apparent in the next section.

Arrivals During Processing

Since there exists no source of messages other than the simulation itself, a technique was necessary for permitting the arrival of messages between increments of  $t_s$ . The technique used is the following:  $t_s$  advances discontinuously by the amount of time required to execute (service) a processing function. After each selection of service time, a routine is entered which checks whether the time of arrival of the message in the input register has been exceeded because of the increment in  $t_s$ . If not, processing continues. If yes, then the message type is determined and the message is logged in. The handling of Flash messages is described in the next section. After the message is entered, the time interval before the arrival of the next message (inter-arrival time) is determined

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\* For further details, see Journal of the American Statistical Association, Vol. 56, No. 295, September 1961, "Bias in Pseudo Random Numbers" by P. Peach.

by generation of a random number and conversion to time by means of a probability distribution.  $t_1$  is incremented by the inter-arrival time and if it is still less than the present  $t_s$ , the message type is determined and the new message is logged in. This procedure is repeated until  $t_1$  for the next message is greater than  $t_s$ . The program then returns to where it left off (a service time had been determined and  $t_s$  incremented), and proceeds until the next incrementation of  $t_s$ .

#### Flash Messages

When it has been determined that a particular message is a Flash, normal processing is interrupted and the Flash message is processed.  $t_s$  is incremented by the processing time. After processing the Flash message, the program proceeds as described in the previous section and a new inter-arrival time is generated.

#### Continuation of Example of Decision Making and Service Time Selection

$t_s$  has jumped from 56.2 to 76.7 sec. Say  $t_1 = 60.0$  sec. The message type subroutine would be entered. If the message were a Regular, it would be stored and the Regular message counter incremented. Then a new  $\Delta t_1$  would be generated, say 15.5 sec. The new  $t_1$  would be 75.5 sec., and therefore, the message type would be determined and the message accepted. Say the message is a Flash.  $T_{FL}$  is determined, say .1 sec., and added to  $t_s$ , making  $t_s = 76.8$  sec. An output is generated indicating the processing of a Flash message. Then a new  $\Delta t_1$  is generated, say 3.0 sec. making  $t_1 = 78.5$ . Since  $t_s < t_1$  the message is not accepted yet, and processing resumes.

#### Output

Each time a message is processed or a Control Cycle request is issued because of the size of the collection batch, an output is generated. The output formats are shown in Fig. 4. The limited format used for the output of Flash and Flight plan messages and Control Cycle requests is due to storage limitations in the computer.

The data is also punched on paper tape for input to an as yet unwritten program which will perform further statistical analysis.

### V. An Example of Simulation Operation

Figure 5 is a sample of the simulation output. The numbers were contrived to illustrate various aspects of simulation operation. A description of the events causing this output is given below. Note the use of the word "output" with regard to a message does not necessarily correspond to actual output of a message, but refers to completion of processing and output by the simulation.

At 150 seconds, a Control Cycle is in operation, and a Task 6 Regular message has been output. The times and queue lengths are as indicated. The time averages relate to Regular messages here. At 152.1, another Task 6 message is output. Note that while this message was in process, one Flight Plan and one Display Request arrived. Thus the total queue in the system actually increased by one after processing one message. At 153.5, a Task 6 message which forced a display was output; i.e., the forced display was output. Note this message arrived earlier than the previous Task 6 message processed, but was delayed until the completion of Task 6 before its processing was completed. There are no messages for Tasks 7-14. Thus at 154.2, a Task 15 message is output. Note it arrived before some Task 6 messages, but was delayed because of its low priority. In this case, one Regular arrived during the processing of the Task 15 message. Therefore, the Regular queue did not decrease.

The new Control Cycle begins, and at 180.0 the first Display of the new cycle is output. The time averages relate to Display Request messages here. Display Request processing continues until the last Display is output at 195.0. At 195.5, the first Regular message of the cycle is output. It is a Task 3 message. While the next Regular message is in process, a Flash message arrives. It is processed immediately (requiring .2 sec.), and output at 195.8. There are no Task 4 messages or Task 5 messages not forcing a display. Therefore, the next output, at 196.2 is a Task 5 message forcing a display. The processing continues.

#### VI. Limitations of the Present Simulation

The simulation was run on the Bendix G-15 located at SDC, Paramus. With the exception of two subroutines (one of them being the random number generator) the entire program was written in Intercom 1000, an interpretive language. Only 1200 locations were available for program and data storage. As a result, many desirable features had to be omitted from the simulation. In the next phase of this simulation effort, a program will be written for a much larger machine, the DPC itself, and it should be possible to eliminate all the limitations discussed. Some present limitations are the following:

In the simulation, messages are categorized only by the task which they cause to operate and later by whether they force a display. In actuality, there are approximately 100 different message types, so that several messages operate the same task. Since there was no room for storage of rules and processing time distribution for each message, the present "grouping" scheme was adopted. Since present message studies give relative frequency of messages by type, further processing is required before this data is input to the simulation.

The DPC requests a Control Cycle when it has collected 250 Regular messages or 125 Display Requests. In the simulation two locations are required for each Regular message (other than Flight Plans) and one location for Flight Plans and Display Requests. In the case of Regulars and Display Requests, these figures must be doubled because one batch is being collected while the previous batch is being processed. The simulation is able to store only 100 Regular, 50 Display Request and 50 Flight Plan messages. This requires 550 of the 1200 available locations. Thus in running the simulation, parameters must be selected in such a manner that steady state queues in excess of these limits do not develop.

As indicated in the section on output, a limited amount of statistical calculation is done by the simulation. It would be valuable to compute certain other statistics as part of the output routine; e.g., length of queue or waiting time such that the probability of exceeding this value is less than P, where P is input at the start of the simulation. These statistics should be computable by message type, message task, or message priority.

The only probability distributions built into the simulation are, discrete, uniform and exponential (Poisson distributed message arrivals are generated by an exponential inter-arrival time distribution). Several functions would be more realistically simulated by distributions which peak at about mid-range.

There is some flexibility built into the present simulation in that the parameters characterizing the probability distributions are input parameters. However, to function effectively as a design aid, a system option selections is required which would enable the designer to vary operational discipline and to select the probability distribution associated with each function.

It is characteristic of the Monte Carlo approach that to obtain statistically meaningful steady state results, the simulation must run "several" times for a given set of parameters, or assuming the process to be ergodic (which seems reasonable in this case after the steady state is reached), the simulation could be run for a "long" simulated time instead. The simulation on the G-15 runs about 12-1 slow; that is, to simulate 30 minutes of DPC time requires 6 hours on the G-15. This precludes the type of production running necessary to obtain statistically meaningful results. Simulation on the DPC should speed up the running time by a factor of between 200 and 1000, making production running practical.

## VII. Some Applications

As an indication of the usefulness of the simulation and to illustrate the kind of questions the designer can ask it, some applications will be presented.

### Control Cycle Request Criteria

In order to make the most efficient use of the DPC, messages should be batched for as long as possible to minimize for a given number of messages, the number of times the Data Preparation task must be operated and the number of times the various tasks must be loaded into core memory. This is particularly important if the task is permanently stored on tape, since the access time is very high. On the other hand, long collection periods mean that the DPC files do not contain the latest data, and that requests for displays are delayed. Thus, it is important to know the tradeoff of computer efficiency and message waiting time vs. batch collection time. One can determine these tradeoffs by running the simulation with various collection times and studying the relevant outputs.

### Processing Time, Input Load

The effect of time required by any processing function can be studied by running the simulation for a variety of values of that parameter. The effect of input frequency can be studied similarly.

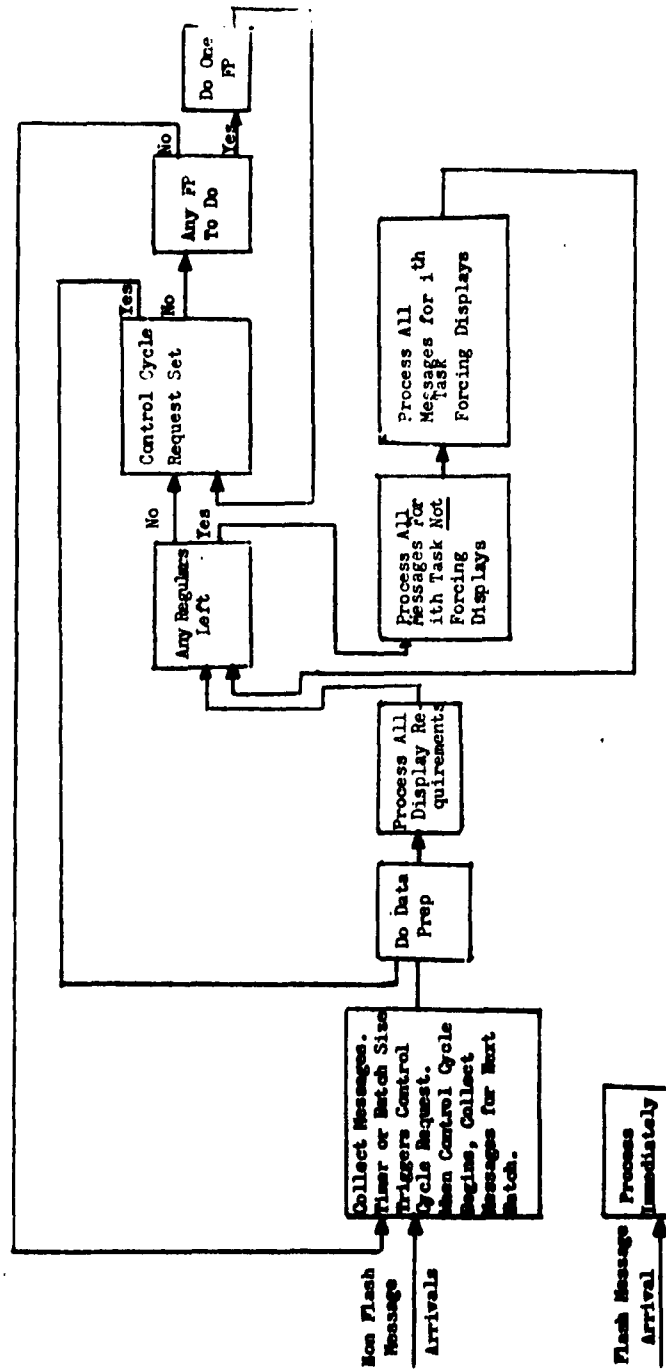
### Message/Task Priority

One of the factors determining the priority which a message or task should be assigned is the waiting time until that message or task is operated. This could be studied (in the next simulation) by outputting statistics on the waiting time for that type of message or task.

### Measures of Effectiveness

Often in "analytic" models only a limited number of measures of effectiveness can be computed; e.g. average queue size, average waiting time, maximum allowable input frequency. In the simulation virtually any statistic of any variable in the system can be determined.

FIGURE 1  
A BLOCK DIAGRAM OF DPC OPERATION



NOTE: 1 - Messages can arrive and be accepted at any time.

2 - After each message is processed the data relating to it is outputted by the simulation.

FIGURE 2

A BLOCK DIAGRAM OF THE SIMULATION

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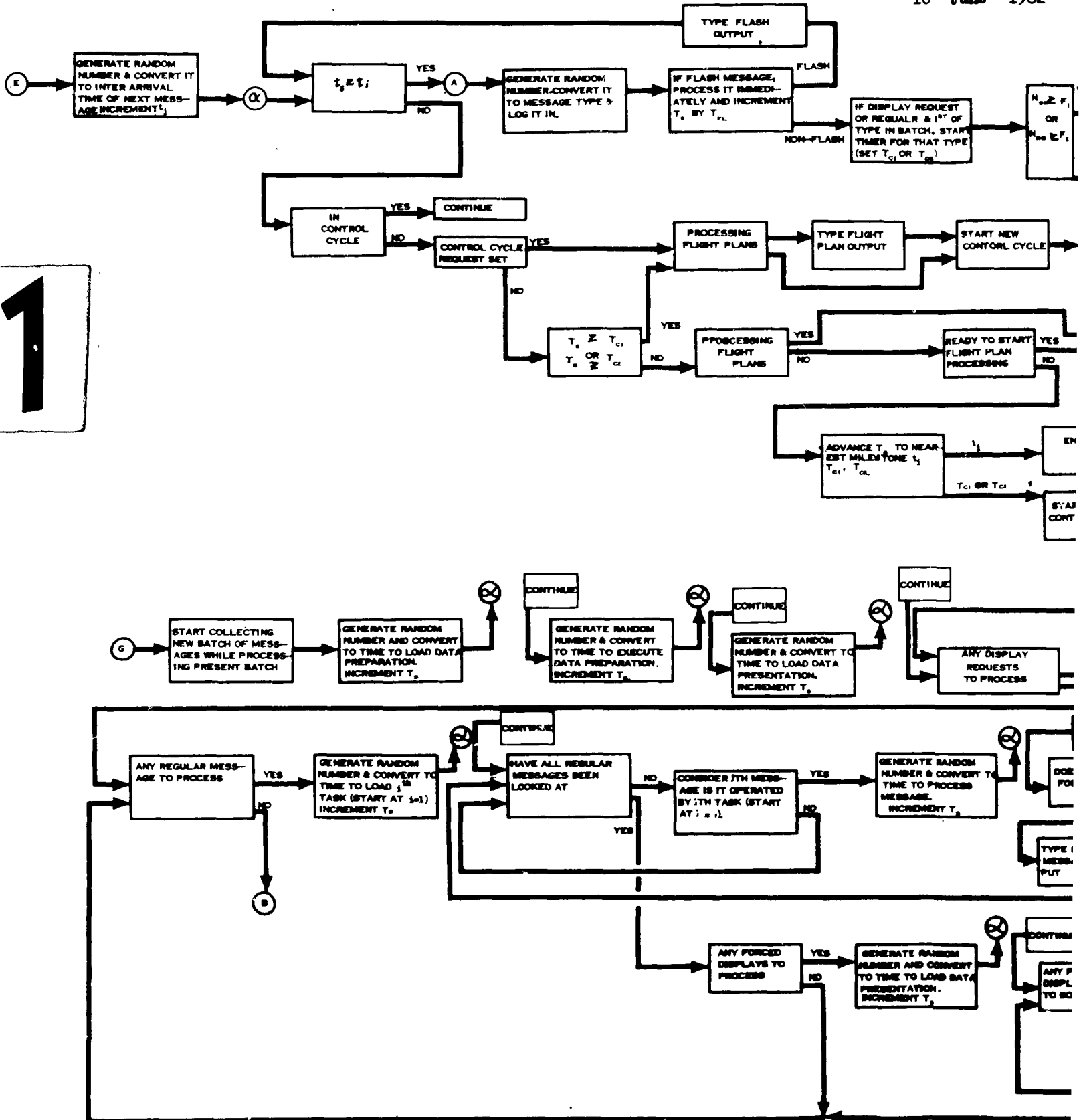






FIGURE 3  
INPUT PARAMETERS

<u>Item</u>	<u>Selection</u>
1 - Inter-arrival time (exponential distribution)	Mean
2 - Message type - Flash, Flight Plan, Display Request, 14 Regular Tasks	Relative Frequency (% of total)
3 - Probability of message forcing display	Probability
4 - Maximum collection time for Display Requests before Control Cycle request	Time
5 - Maximum collection time for Regular messages before Control Cycle request	Time
6 - Maximum number of Display Requests in batch before Control Cycle request	Number
7 - Maximum number of Regular messages in batch before Control Cycle request	Number
8 - Task entry time, common to all tasks (uniform distribution)	Lower Limit Width
9 - Time to execute Data Preparation (uniform distribution)	Lower Limit Width
10 - Time to process (generate) a display, including forced display (exponential distribution)	Mean
11 - Time to process a Regular Message, common to all Regular messages (uniform distribution)	Lower Limit Width
12 - Time to process a Flash message (uniform distribution)	Lower Limit Width
13 - Time to process a Flight Plan message (exponential distribution)	Mean

FIGURE 4  
OUTPUT FORMATS

Standard Format (Display Request & Regular)

$t_{\text{output}}$	Message type <sup>1,2</sup>	$t_1$	$t_{\text{tot}}$	$t_{\text{tot,avg}}$	
$t_w$	$t_{w,avg}$	$N_{\text{FP}}$	$N_{\text{DR}}$	$N_{\text{R}}$	$N_{\text{total}}$

Flight Plan Format

$t_{\text{output}}$	Message Code for Flight Plan 201.	$t_1$			
		$N_{\text{FP}}$	$N_{\text{DR}}$	$N_{\text{R}}$	$N_{\text{total}}$

Flash Format

$t_{\text{output}}$	Message Code for Flash 1.	$t_{\text{tot}}$
---------------------	------------------------------	------------------

Control Cycle Request Format

$t_{\text{request}}$	Number of Messages in Batch Causing Request. $N_{\text{SB}}$ or $N_{\text{RB}}$
----------------------	--

Notes

1 - Regular Message Type 301, 401,-----1601.  
If Forced Display 302, 402,-----1602.

2 - Display Request Type 101.

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FIGURE 5  
SAMPLE SIMULATION OUTPUT

150 45.0	601 47.0	104 12	46.0 7	48.0 67	86
152.1 26.5	601 46.6	125 13	27.1 8	47.5 66	87
153.5 37.0	602 46.5	115 13	38.5 8	47.4 65	86
154.2 45.6	1501 46.5	108 13	46.2 8	47.4 65	86
154.9	201	105 12	8	65	85
155.5	201	120 11	9	65	85
156.0	10.0				
157.1	201	128 11	10	66	87
180.0 47.5	101 33.7	131 12	49.0 14	35.0 73	99
180.9 42.9	101 33.9	136 12	44.9 13	35.3 73	98
.	.	.	.	.	.
.	.	.	.	.	.
195.0 38.1	101 34.8	156.0 14	39.0 2	37.0 80	96
195.5 56.9	301 46.7	138 14	57.5 2	47.6 79	95
195.8	1.	.2			
196.2 58.2	502 46.9	135 14	61.2 3	47.9 78	95

GLOSSARY

$t_s$	- present time in the simulation
$t_i$	- time of arrival at the DPC of an input message
$t_{tot}$	- total time spent in the DPC ( $t_s$ of message output - $t_i$ ) by a particular message
$t_{tot,avg}$	- average $t_{tot}$ for a class of messages; e.g., Display Request, Regular (non Flight Plan)
$t_w$	- waiting time in the DPC for a particular message ( $t_s$ of message output - $t_s$ of start of processing of that message)
$t_{w,avg}$	- average $t_w$ , similar to $t_{tot,avg}$
Processing Batch	- that group of messages which the present Control Cycle is operating
Collection Batch	- that group of messages being collected for processing in the next operation of a Control Cycle
$N_{FP}$	- number of Flight Plan messages awaiting processing
$N_S$	- total number of Display Requests awaiting processing including those in the processing batch and in the collection batch
$N_R$	- similar to $N_S$ but applies to Regular messages
$N_{total}$	- total number of messages awaiting processing ( $N_{FP} + N_S + N_R$ )
$N_{SB}$	- number of Display Requests in Collection Batch
$N_{RB}$	- number of Regular messages in Collection Batch
$T_1$	- time interval from arrival of first Display Request in Collection Batch to time a request for operation of a Control Cycle is made
$T_2$	- similar to $T_1$ but for Regular messages

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- $T_{C1}$  -  $t_1$  of first Display Request in Collection Batch +  $T_1$
- $T_{C2}$  -  $t_1$  of first Regular message in Collection Batch +  $T_2$
- $F_1$  - number of Display Requests in Collection Batch which  
cause Control Cycle request
- $F_2$  - number of Regular messages in Collection Batch which  
cause Control Cycle Request.



## INTERCOM PROGRAM

Prepared by \_\_\_\_\_

Page \_\_\_\_ of \_\_\_\_

Date: \_\_\_\_\_

PROBLEM DPC SIMULATION

Line: \_\_\_\_\_

NOTES	Location	K	OP CODE	Address	(A) or (AA)
(C) Reset In Cycle Indicator	0700		49	11 8	
Go to (C)	701		29	8 90	
(T')	702		42	11 7	
Type $t_s$	703		33	21 1	
	704	5	49	12	
	705		42	11 68	
Type Message Type	706		33	21 1	
Continue output at (1007)	707		29	10 7	
(E) START OF PROGRAM	708		40	11 13	
Set $T_{IA}$ for exponential routine	709		49	11 71	
	710		42	11 58	
Set IA Indicator	711		49	11 31	
Generate random no.	712		8	11 84	
Convert to IA time, $T_{IA}$ . Go To (EX)	713		28	9 85	
	714		42	11 5	
	715		43	11 75	
Store $t_i$ . NEW = $t_i$ . OLD + $T_{IA}$	716		49	11 69	
	717		49	11 5	
	718		42	11 7	
(K)	719		41	11 5	
If $t_s \geq t_i$ to to (A)	720		20	9 2	
	721		42	11 8	
If not in cycle, go to L+2	722		23	7 24	
If in cycle - return	723		16		
	724		42	11 23	
If cycle req. not set - Go to L+3	725			7 28	

INTERCOM PROGRAM

Prepared by \_\_\_\_\_

Page \_\_\_\_\_ of \_\_\_\_\_

Date: \_\_\_\_\_

PROBLEM \_\_\_\_\_

DPC SIMULATION

Line: \_\_\_\_\_

NOTES

Location

K

OP  
CODE

Address

(A) or (AA)

If cycle req. set. Go to (FP7)

726

28

10 80

Cycle req. set - Go to (G)

727

29

7 51

728

42

11 7

729

41

11 27

If  $t_s \geq T_{01}$ , go to L-4

730

20

7 26

731

42

11 7

Finish test routine at (1066)

732

29

10 66

(J) Subroutine to advance  $t_s$  to  
nearest milestone.

733

42

11 27

734

41

11 29

If  $T_{01} \geq T_{02}$ , go to L-10

735

20

7 45

$T_{01} < T_{02}$

736

42

11 69

737

41

11 27

If  $t_1 \geq T_{01}$ , go to L-4

738

20

7 42

739

42

11 5

Set  $t_s = t_1$

740

49

11 7

Go to (A)

741

29

9 2

$t_1 \geq T_{01}$

742

42

11 27

Set  $t_s = T_{01}$

743

49

11 7

Go to (G)

744

29

7 51

$T_{02} < T_{01}$

745

42

11 69

746

41

11 29

If  $t_1 \geq T_{02}$ , go to L-2

747

20

7 49

If  $t_1 < T_{02}$ , go to L-9

748

29

7 39

749

42

11 29

Set  $t_s = T_{02}$

750

49

11 7

(G) Start Control Cycle

751

42

11 59

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SDC		INTERCOM PROGRAM				Page: of
PROBLEM		Prepared by				Date:
DPC SIMULATION		Line:				
NOTES	Location	K	OP CODE	Address	(A) or (AA)	
Set $T_{c1}$ large	752		42	11 27		
Set $T_{c2}$ large	753		49	11 29		
	754		42	11 58		
Set In Cycle Indicator	755		49	11 8		
	756		42	11 99		
Set no. Display Req.	757		49	11 39		
	758		42	11 08		
Set no. reg. in Cycle	759		49	11 93		
Set no. reg. LEFT in Cycle	760		49	11 40		
	761		41	21 1		
Reset Task Ident. to 0	762		49	11 99		
Reset Cycle Req. to 0	763		49	11 23		
Reset Reg. Input Ctr. to 0	764		49	11 88		
Reset Disp. Reg. Input Ctr. to 0	765		49	11 89		
Set index registers for collection and processing batches.	766	1	74	2		
	767	1	70			
	768	7	70			
$L + 10$	769	1	77	7 79		
	770	1	73			
	771	7	73	2		
	772	1	74	1		
	773	3	70			
	774	8	70			
$L + 7$	775	3	77	7 02		
	776	3	73			
	777	8	73	1		



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## INTERCOM PROGRAM

Prepared by \_\_\_\_\_


Page \_\_\_\_\_ of \_\_\_\_\_

Date: \_\_\_\_\_

PROBLEM: DFC SIMULATION

Line: \_\_\_\_\_

NOTES	Location	K	OP CODE	Address	(A) or (AA)
Go to (D)	778		29	7 83	
	779	1	73	2	
	780	7	73		
L-9	781		29	7 72	
	782	8	73		
(D)	783		8	11 84	
To enter Data Prep., go to (TE)	784		26	10 53	
	785		8	11 84	
To execute Data Prep., go to (TE)	786		26	10 88	
	787		8	11 84	
To enter Data Prep., go to (TE)	788		26	10 53	
	789		42	11 39	
If no. Disp.Req. Left = 0 Go to (M-2)	790		23	8 18	
	791		41	11 58	
Store no. Disp.Req. Left to do	792		49	11 39	
(R)	793		42	11 7	
Store time processing started on ith Disp. Req.	794		49	11 61	
	795		40	11 17	
Store Disp.Proc. for exp. sub-routine	796		49	11 71	
	797		8	11 84	
Convert to display processing time Go to (EX)	798		26	9 85	
DISP. OUTPUT	799		42	11 97	
Message Type	800		49	11 68	
	801	8	42	17	
Time of arrival, $t_1$	802		49	11 69	
	803		42	11 62	

		INTERCOM PROGRAM			Page <u>    </u> of <u>    </u>
		Prepared by <u>                    </u>			Date: <u>            </u>
PROBLEM <u>DPC SIMULATION</u>					Line: <u>            </u>
NOTES	Location	K	OP CODE	Address	(A) or (AA)
Total $t_{tot}$ for displays since $t_s = 0$ .	804		49	11 1	
	805		42	11 35	
Total displays processed since $t_s = 0$ .	806		49	11 2	
	807		42	11 63	
Total $t_w$ for displays since $t_s = 0$ .	808		49	11 3	
Go to (T') to continue output.	809		26	7 2	
	810		42	11 1	
New total $t_{TOT}$	811		49	11 62	
	812		42	11 2	
New total no. of displays processed.	813		49	11 35	
	814		42	11 3	
New total $t_w$	815		49	11 63	
Go to (T'') to finish output	816		26	10 33	
Increment #8 WD Base & look for next display. Go to (R-4).	817	8	76	7 89	
	818		42	11 32	
	819		49	11 37	
	820		42	11 40	
If no Regular's, go to (C')	821		23	7	
	822	2	70		
	823	7	70		
Subroutine-Reset #7 CH Base	824		8	10 72	
	825		42	11 37	
	826		43	11 11	
Set task number.	827		49	11 37	
(S)	828	7	42	13	
	829		41	11 37	

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SDC		INTERCOM PROGRAM			Page ____ of ____
PROBLEM DPC SIMULATION		Prepared by _____			Date: _____
					Line: _____
NOTES	Location	K	OP CODE	Address	(A) or (AA)
If task done, go to (N)	830		22	8 48	
	831		41	11 11	
If task hasn't been reached yet, Go to (N).	832		20	8 48	
	833		42	11 7	
Store time processing started in 1st message of 1st task	834		49	11 01	
	835		8	11 84	
Convert to time to process regular message, go to (Tpr)	836		26	10 92	
	837		8	11 84	
	838		41	11 19	
If no forced display, go to (T)	839		20	8 56	
	840	7	42	13	
Store message type forcing display.	841	2	49	17 50	
	842	7	42	13 1	
Store $t_1$ of message forcing display.	843	2	49	17 51	
	844		42	11 96	
	845		43	11 58	
Increment no. forced displays to do	846		49	11 96	
Increment #2-Go to (N).	847	2	76	8 48	
(N)	848		42	11 78	
	849		42	11 53	
Increment no. Regular's in Cycle looked at.	850		49	11 78	
	851		41	11 90	
If no. Regular's looked at=no. in cycle, Go to (B).	852		23	8 45	
Increment #7. Look at next message. Go to (S).	853	7	76	8 28	
	854	7	70		
Go to (S)	855	7	77	8 29	

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## INTERCOM PROGRAM

Prepared by \_\_\_\_\_

Page \_\_\_\_ of \_\_\_\_

Date: \_\_\_\_\_

PROBLEM DPC SIMULATION

Line: \_\_\_\_\_

NOTES	Location	K	OP CODE	Address	(A) or (AA)
(T) OUTPUT REGULAR MESSAGE	856		42	11 40	
	857		41	11 58	
Decrement no. Regular's left in cycle.	858		49	11 40	
	859	7	42	13	
Transfer message type.	860		49	11 68	
	861	7	42	13 1	
Transfer $t_1$ of message	862		49	11 69	
Go to (T <sup>3</sup> )	863		23	17 82	
Go to (N)	864		23	9 49	
(B) Reset no. Regular's looked at.	865		49	11 78	
Reset Forced display Register- #2.	866	2	70		
(P)	867		42	11 96	
If no Force Display, go to (M)	868		23	8 20	
	869		8	11 84	
Enter Data Pres. for forced display - Go to (TE)	870		26	10 53	
	871		42	11 7	
Store time processing started for 1th forced display.	872		49	11 61	
	873		42	11 17	
Store $\mu$ for display processing.	874		49	11 71	
	875		8	11 84	
Convert to time to process forced display. Go to (EX)	876		26	9 85	
	877		42	11 40	
	878		41	11 58	
Decrement no. Reg. left in cycle.	879		49	11 40	
	880	2	42	17 50	
	881		43	11 58	

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SDC		INTERCOM PROGRAM				Page <u>    </u> of <u>    </u>
PROBLEM: DPC SIMULATION		Prepared by <u>                    </u>				Date: <u>            </u>
Line: <u>            </u>						
NOTES	Location	K	OP CODE	Address	(A) or (AA)	
Transfer message type with Forced Display Indicator.	882		49	11 03		
	883	2	42	17 51		
Transfer message <sup>t</sup> <sub>1</sub> .	884		49	11 69		
	885		42	11 96		
	886		41	11 58		
Decrement no. Forced Displays.	887		49	11 96		
Go to (T <sup>3</sup> ) for output.	888		28	17 32		
Go to (P) for next forced display	889	2	76	8 67		
(C)	890		42	11 58		
Set Ready for Flight Plan Ind.	891		49	11 81		
Go to (K+2)	892		29	7 21		
(C)	893		42	11 87		
Transfer no. Flight Plane. FP	894		49	11 99		
If no FP, go to (J)	895		23	7 30		
	896		41	11 58		
Decrement no. FP	897		49	11 87		
	898		40	11 20		
Store <sup>7</sup> / <sub>4</sub> to process FP.	899		49	11 71		
	900		8	11 84		
Convert to time to process FP. Go to (EX).	901		29	9 85		
	902		8	11 84		
Determine Message Type	903		49	11 74		
	904	6	70			
	905		42	11 58		
Set message type counter to 001.	906		49	11 67		
Go to L + 4	907		29	9 11		

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SDC		INTERCOM PROGRAM				Page of
PROBLEM		Prepared by				Date:
DPC SIMULATION		Line:				
NOTES	Location	K	OP CODE	Address	(A) or (AA)	
	908		42	11 67		
	909		43	11 11		
Increment message type counter by 100.	910		49	11 67		
	911	6	42	11 42		
	912		41	11 74		
If message type not reached, go to L+10.	913		22	9 23		
	914		42	11 67		
Store Message Type	915		49	11 68		
	916		41	11 58		
If Flash, go to (AF)	917		23	9 24		
	918		41	11 11		
If Display Request, go to (AS)	919		23	9 57		
	920		41	11 11		
If Flight Plan, go to (FP)	921		23	9 77		
Regular. Go to (AR)	922		29	9 33		
Go to L-15	923	6	76	9 8		
(AF)	924		8	11 84		
Convert to Flash Process Time. Go to (TFL)	925		28	17 75		
	926		43	11 75		
Type Output Time for Flash	927		33	21 1		
Type Message Type	928		33	11 68		
Type $t_{FL}$	929		38	11 75		
	930		30	1		
Go to (E)	931		29	7 8		
	932					
(AR)	933		42	11 68		

SDC		INTERCOM PROGRAM				Page ___ of ___
PROBLEM		DPC SIMULATION				Date: _____
Prepared by _____						Line: _____
NOTES	Location	K	OP CODE	Address	(A) or (AA)	
	934	1	49	13		
	935		42	11 5		
	936	1	49	13 1		
	937		42	11 88		
If no Regulars, go to L+2	938		23	9 40		
L+4	939		29	9 43		
	940	1	42	13 1		
	941		43	11 92		
Set T <sub>2</sub>	942		40	11 29		
L+3	943	1	76	9 46		
	944	1	70			
L+1	945	1	77	9 46		
	946		42	11 88		
	947		43	11 58		
Increment Regular Counter	948		49	11 88		
	949		41	11 94		
If N <sub>RB</sub> < F <sub>1</sub> - Go to (E)	950		22	7 8		
Type t <sub>1</sub>	951		33	11 05		
Type no. in Regular Counter	952		38	11 88		
	953		30	00 01		
(Q)	954		42	11 58		
	955		49	11 23		
Go to (E)	956		29	7 8		
(As)	957		42	11 5		
	958	3	49	17		
	959		42	11 89		

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 SDC PROBLEM		INTERCOM PROGRAM Prepared by _____ DPC SIMULATION			Page _____ of _____ Date: _____ Line: _____	
NOTES	Location	K	OP CODE	Address	(A) or (AA)	
L + 2	960		23	9 62		
L + 4	961		29	9 65		
	962	3	42	17		
	963		43	11 91		
Set $T_{cl}$	964		49	11 27		
L + 3	965	3	76	9 69		
	966	3	70			
L + 1	967	3	77	9 62		
	968		42	11 80		
	969		43	11 53		
Increment Disp. Req. Counter	970		49	11 89		
	971		41	11 90		
If $N_3 < F_2$ , Go to (E)	972		24	7 10		
Type $t_s$	973		33	11 05		
Type no. in Disp. Req. Counter	974		35	11 89		
	975		30	00 01		
Go to (Q)	976		29	9 54		
(FP)	977		42	11 11		
	978	4	49	18 37		
	979		42	11 37		
	980		43	11 58		
Increment (Fp) Counter	981		49	11 87		
Increment #4, Go to (E)	982	4	76	7 8		
Reset #4	983	4	70			
Go to (E)	984		29	7 8		
(EX) Exp. Distribution	985		49	11 74		



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## INTERCOM PROGRAM

Prepared by \_\_\_\_\_

Page \_\_\_\_ of \_\_\_\_

Date: \_\_\_\_\_

PROBLEM DPC SIMULATION

Line: \_\_\_\_\_

NOTES	Location	K	OP CODE	Address	(A) or (AA)
	986		41	10 04	
	987		47	11 74	
	988		49	11 74	
	989		44	21 01	
	990		49	09 32	
	991		44	11 12	
	992		43	10 06	
	993		44	09 32	
	994		43	10 05	
	995		44	09 32	
	996		43	10 04	
	997		44	09 32	
	998		43	10 03	
	999		44	11 74	
	1000		48	11 71	
$\Delta t = - \frac{\ln(1-P)}{\mu}$	1001		49	11 75	
Go to (U) routine following select T.	1002		29	10 56	
	1003				
	1004				
	1005				
	1006				
Second part of (T') routine.	1007	5	49	12 1	
	1008		42	11 69	
Type t <sub>1</sub> for message.	1009		33	21 1	
	1010	5	49	12 2	
	1011		42	11 7	

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SDC		INTERCOM PROGRAM				Page ___ of ___
PROBLEM		Prepared by _____				Date: _____
DPC SIMULATION		Line: _____				
NOTES	Location	K	OP CODE	Address	(A) or (AA)	
	1012		41	11 09		
Type $t_{TOT}$ for message.	1013		31	21 1		
	1014	5	49	12 3		
	1015		43	11 1		
Store total $t_{TOT}$ for all messages in class.	1016		49	11 1		
	1017		42	11 2		
	1018		43	11 58		
Store total processed in class	1019		49	11 2		
	1020		47	11 1		
Type $t_{TOT}$ (AVG)	1021		38	21 1		
	1022	5	49	12 4		
	1023		42	11 61		
	1024		41	11 09		
Type $t_w$	1025		31	21 1		
	1026	5	49	12 5		
	1027		43	11 3		
Store total $t_w$ for all messages in class.	1028		49	11 3		
	1029		48	11 2		
Type $t_w$ (AVG)	1030		33	21 1		
	1031	5	49	12 6		
	1032		16			
( $T''$ )	1033		42	11 87		
Type $N_{FP}$	1034		31	21 1		
	1035	5	49	12 7		
	1036		42	11 89		
	1037		43	11 39		

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PROBLEM

DPC SIMULATION

## INTERCOM PROGRAM

Prepared by \_\_\_\_\_

Page \_\_\_\_ of \_\_\_\_

Date: \_\_\_\_\_

Line: \_\_\_\_\_

NOTES	Location	K	OP CODE	Address	(A) or (AA)
Type $N_S$	1038		33	21 1	
	1039	5	49	12 8	
	1040		42	11 88	
	1041		43	11 40	
Type $N_R$	1042		33	21 1	
	1043	5	49	12 9	
	1044	5	43	12 8	
	1045	5	43	12 7	
Type $N_{TOT} = N_R + N_S + N_{FP}$	1046		33	21 1	
	1047		30	2	
	1048	5	49	12 10	
	1049	5	76	10 52	
	1050	5	70		
Punch stored output.	1051		30	12 99	
	1052		18		
Task entry (TE)	1053		44	11 14	
PA + lower limit	1054		43	11 10	
Store $\Delta t$	1055		49	11 75	
(U) IA indicator.	1056		42	11 31	
	1057		41	11 58	
If not an IA select, Go to L+H.	1058		22	10 62	
	1059		41	21 1	
Reset IA Indicator.	1060		49	11 31	
	1061		18		
(U) $\Delta t$ is for processing, not for IA TIME	1062		42	11 75	
	1063		43	11 7	

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SDC		INTERCOM PROGRAM			Page ____ of ____
PROBLEM: DPC SIMULATION		Prepared by _____			Date: _____
Line: _____					
NOTES	Location	K	OP CODE	Address	(A) or (AA)
Store new $t_s$	1064		49	11 7	
Go to (K)	1065		29	7 19	
Remainder of test routine.	1066		41	11 29	
Go to "Cycle request set" if $t_s \geq t_{a2}$	1067		20	7 26	
	1068		42	11 99	
If =0, not doing FP, Go to (J)	1069		23	17 70	
Go to output of FP	1070		28	10 82	
Go to (C')	1071		29	8 93	
	1072		*		
	1073		*		
	1074		*		
	1075		*		
	1076		*		
	1077		*		
	1078		*		
	1079		*		
(FP)? If >0, doing FP, Go to L+2	1080		42	11 99	
	1081		23	10 61	
Type $t_s$	1082		33	11 7	
Type FP code	1083		33	11 98	
Type $t$ in $t_s$	1084	9	38	18 50	
Increment #9, Go to L+2	1085	9	76	10 87	
	1086	9	70		
Go to (OUTPUT FP)	1087		29	17 67	
( $T_{DP}$ )	1088		44	11 15	
	1089		43	11 16	



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## INTERCOM PROGRAM

Prepared by \_\_\_\_\_

Page \_\_\_\_ of \_\_\_\_

Date: \_\_\_\_\_

PROBLEM

DPC SIMULATION

Line: \_\_\_\_\_

NOTES	Location	K	OP CODE	Address	(A) or (AA)
(OUTPUT FP)	1767		30	2 1	
	1768		26	10 33	
	1769		18		
	1770		42	11 81	
If not ready for FP and not in FP, go to (J).	1771		23	7 33	
	1772		41	21 1	
Reset "Ready for FP" Indicator	1773		49	11 81	
If not in FP but ready to start go to (K).	1774		29	8 93	
(T <sub>FL</sub> )	1775		44	11 21	
	1776		43	11 18	
T <sub>FL</sub> = PA + lower limit	1777		49	11 75	
	1778		43	11 7	
t <sub>s</sub> new = t <sub>s</sub> old + T <sub>FL</sub>	1779		49	11 7	
	1780		42	11 5	
	1781		18		
(T <sup>3</sup> )	1782		42	11 77	
Total t <sub>TOT</sub> for Reg. since t <sub>s</sub> = 0	1783		49	11 1	
	1784		42	11 36	
Total Reg. done since t <sub>s</sub> = 0	1785		49	11 2	
	1786		42	11 79	
Total t <sub>y</sub> for Reg. since t <sub>s</sub> = 0	1787		49	11 3	
Go to (T')	1788		26	7 2	
	1789		42	11 1	
New total t <sub>TOT</sub>	1790		49	11 77	
	1791		42	11 2	
New total no. Reg. processed.	1792		49	11 36	



# INTERCOM PROGRAM

Prepared by \_\_\_\_\_

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**Date:** \_\_\_\_\_


Line: \_\_\_\_\_

PROBLEM DPC SIMULATION[illegible]

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**SDC**

**INTERCOM PROGRAM**

Prepared by \_\_\_\_\_

Page \_\_\_\_ of \_\_\_\_

Date: \_\_\_\_\_

Line: \_\_\_\_\_

PROBLEM Index Register Settings

NOTES	Location	K	OP CODE	Address	(A) or (AA)
		1	70	00 00	
		1	71	00 02	
		1	72	00 99	
		1	73	00 00	
		1	74	01 00	
		1	75	03 00	
		2	70	00 00	
		2	71	00 02	
		2	72	00 65	
		2	73	00 00	
		3	70	00 00	
		3	71	00 01	
		3	72	00 49	
		3	73	00 00	
		3	74	01 00	
		3	75	01 00	
		4	70	00 00	
		4	71	00 01	
		4	72	00 49	
		4	73	00 00	
		5	70	00 00	
		5	72	00 98	
		5	73	00 00	
		6	70	00 00	
		6	71	00 01	
		6	72	00 16	



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## INTERCOM PROGRAM

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Prepared by \_\_\_\_\_

Date: \_\_\_\_\_

**PROBLEM:** Index Register Settings

Time: \_\_\_\_\_

[illegible]

**SDC**

Q-150  
PROGRAM PROBLEM

Proposed by \_\_\_\_\_  
Date: \_\_\_\_\_  
Line 10

CHANNEL BASE ASSIGNMENT

0	1	2	3	L	P	Y	N	C	S	D	BP	NOTES
4	5	6	7	72		01	73	3	13	28		Clear and subtract CH base of index register 7 to AR (accumulator later)
8	9	10	11									
12	13	14	15	73		74	75	1	10	29		Add constant in 1074 to the AR.
16	17	18	19									
20	21	22	23	74	<	00	00	0	20	>		Constant = (.0000020)
24	25	26	27									
28	29	30	31	75		77	77	0	22	31		Test if sign of AR negative? If yes, go to 1075. If no, go to 1077.
32	33	34	35									
36	37	38	39	76		01	96	0	28	13		Store AR in CH base of index register 7.
40	41	42	43									
44	45	46	47	77		01	96	0	29	13		Store 2580 in CH base of index register 7.
48	49	50	51									
52	53	54	55	78		79	76	0	10	28		Transfer contents of address 1079 to the AR.
56	57	58	59									
60	61	62	63	79	<	00	00	0	10	>		Constant = (.0000040)
64	65	66	67									
68	69	70	71	96		98	98	0	29	31		Test the overflow indicator? If yes, go to 1099. If no, go to 1096.
72	73	74	75									
76	77	78	79	98	W	00	87	0	21	31		Return to Intercom.
80	81	82	83	99	W	00	87	0	21	31		Return to Intercom.
84	85	86	87									
88	89	90	91									
92	93	94	95									
96	97	98	99									
100	101	102	103									
104	105	106	107									


**NOTE:**

Contents of the CH base of index register 7 is stored in address 11 01.

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												Page <u>  </u> of <u>  </u>
G-150 Random Number Generator PROGRAM PROBLEM: $X_{n+1} = (2^{41}) X_n + M \text{ MOD } (2^{28})$												Date: <u>          </u>
												Line <u>  11  </u>
0	1	2	3	L	P	Y	N	C	S-	D	BP	NOTES
4	5	6	7	84		85	90	0	19	21		BEGIN: $X_n \rightarrow 2101$
8	9	10	11	85	<	7Z	ZZ	Z	ZZ	>		< $X_r$ >
12	13	14	15	90		93	00	0	20	23		2001 $\rightarrow$ 2301
16	17	18	19	00		03	04	0	23	31		Clear 2 word registers
20	21	22	23	04		05	06	1	21	28		$X_n \rightarrow$ AR
24	25	26	27	06		07	09	0	28	24		$X_n \rightarrow$ MQ <sub>1</sub>
28	29	30	31	09		14	22	0	26	31		$2^7 X_n$
32	33	34	35	22		23	24	1	24	29		$(2^7+1) X_n$
36	37	38	39	24		25	26	1	19	29		$(2^7+1) X_n + M = X_{n+1}$
40	41	42	43	25	<	X8	VO	W	XY	>		< M >
44	45	46	47	26		27	28	2	28	28		$X_{n+1}$
48	49	50	51	28		29	30	1	28	21		$X_{n+1}$   $\rightarrow$ 2101
52	53	54	55	30		33	34	0	19	20		Extractor $\rightarrow$ 2001
56	57	58	59	33	<	ZZ	WO	0	00	>		< Extractor >
60	61	62	63	34		37	38	0	31	24		EXTRACT ( $X_{n+1}$ ) $\rightarrow$ MQ <sub>1</sub>
64	65	66	67	38		39	41	0	29	28		SET AR = 0
68	69	70	71	41		V2	60	0	27	31		Normalize MQ <sub>1</sub>
72	73	74	75	60		61	64	0	21	22		2101 $\rightarrow$ 2201
76	77	78	79	64		65	66	1	19	29		ADD exponent
80	81	82	83	65	<	00	00	0	80	>		< exponent >
84	85	86	87	66		69	70	1	24	29		Floating point Nbr. ( $X_{n+1}$ )
88	89	90	91	70		73	76	0	23	20		Reset 2001
92	93	94	95	76		77	80	1	28	21		$X_{n+1} \rightarrow$ 2101
96	97	98	99	80		82	82	0	27	31		Reset overflow indicator
00	01	02	03	82		85	86	0	22	11		$X_{n+1} \rightarrow$ 1985
04	05	06		83		85	86	0	22	11		$X_{n+1} \rightarrow$ 1985

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[illegible]

DESCRIPTION OF STORAGE LOCATIONS

LOCATION	ITEM
0932	Working Storage
1003	2
1004	.66667
1005	.4
1006	.28571
1101	OUTPUT Total Time in System
1102	OUTPUT Total Messages of that Kind Processed
1103	OUTPUT Total Waiting Time
1104	*
1105	$t_1$
1106	*
1107	$t_s$
1108	In Cycle Indicator
1109	*
+ 1110	Lower Limit (Enter Task)
1111	100
1112	.22222
+ 1113	$\wedge$ (IA TIME)
+ 1114	$\Delta$ (Enter Task)
+ 1115	$\Delta$ (Execute Data Preparation)
+ 1116	Lower Limit (Execute Data Preparation)
+ 1117	$\wedge$ (Data Presentation)

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+ 1118	Lower Limit (Process Flash)
+ 1119	P (Probability that message forces display)
+ 1120	✎ (Process Flight Plan)
+ 1121	△ (Process Flash)
1122	*
1123	Cycle Request Indicator
1124	*
1125	*
1126	*
1127	T <sub>c1</sub>
1128	*
1129	T <sub>c2</sub>
1130	*
1131	IA Indicator
1132	200
1133	*
1134	*
1135	OUTPUT No. Display Requests Processed
1136	OUTPUT No. Regular Processed
1137	Task No. (Regular) = Task Identification
1138	*
1139	Total Display Requests in Processing Batch
1140	Total Regular's left in Processing Batch
	*

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+ 1142	N <sub>1</sub>
+ 1143	N <sub>2</sub>
+ 1144	N <sub>3</sub>
+ 1145	N <sub>4</sub>
+ 1146	N <sub>5</sub>
+ 1147	N <sub>6</sub>
+ 1148	N <sub>7</sub>
+ 1149	N <sub>8</sub>
+ 1150	N <sub>9</sub>
+ 1151	N <sub>10</sub>
+ 1152	N <sub>11</sub>
+ 1153	N <sub>12</sub>
+ 1154	N <sub>13</sub>
+ 1155	N <sub>14</sub>
+ 1156	N <sub>15</sub>
+ 1157	N <sub>16</sub>
1158	1
1159	10 <sup>10</sup>
1160	*
1161	Processing Start Time
1162	Total Time in System - Display Request
1163	Total Waiting Time - Display Request
1164	*
1165	*
1166	*

1167	Message Type Counter
1168	Message Type
1169	OUTPUT Message $T_1$
1170	*
1171	$\Delta$ (in EX)
+ 1172	$\Delta$ (Process Regular)
+ 1173	Lower Limit (Process Regular)
1174	P from Random No. (in EX)
1175	$\Delta t$ , OUTPUT from "Convert to Time" routine
1176	*
1177	Total Time in System - all Regular's
1178	No. Regular's looked at
1179	Total Waiting Time - all Regular's
1180	*
1181	"Ready for Flight Plan" Indicator
1182	*
1182	*
1184	*
1185	*
1186	*
1187	No. Flight Plans in System
1188	No. of Regular's in Collection Batch
1189	No. of Display Requests in Collection Batch
1190	*
+ 1191	$T_1$



+ 1192	$T_2$
1193	No. Regular's originally in Processing Batch
+ 1194	$F_1$
+ 1195	$F_2$
1196	No. Forced displays left to do
1197	Display Request Code - 101
1198	Flight Plan Code - 201
1199	Flight Plans in Process Indicator

<u>LOCATION</u>		<u>INDEX REGISTER</u>
1300-1499	Regular's Batch 1	1,7
1500-1699	Regular's Batch 2	1,7
1760-1789	Forced Displays	2
1700-1749	Display Requests Batch 1	3,8
1800-1849	Display Requests Batch 2	3,8
1850-1899	Flight Plans	4,9
1200-1298	Output	5
	Message Type	6

NOTES:

1. \* Location is used in random number generator subroutine.
2. + Item is input parameter.
3. Locations 1142-1157 are for probabilities of message types
  - $N_1 - 0$  = Flash
  - $N_2 - N_1$  = Display Request
  - $N_3 - N_2$  = Flight Plan

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$N_4 - N_3 = \text{Regular Task 1}$

$\vdots$

$1 - N_{16} = \text{Regular Task 14.}$